United States Patent [19]

Kasugayama et al.

[11] **4,306,245**

[45] **Dec. 15, 1981**

[54] **LIQUID JET DEVICE WITH CLEANING PROTECTIVE MEANS**

[75] Inventors: **Yukio Kasugayama; Masatsune Kobayashi,** both of Yokohama; **Shigeyuki Matsumoto; Yoshihumi Hattori,** both of Kawasaki, all of Japan

[73] Assignee: **Canon Kabushiki Kaisha,** Tokyo, Japan

[21] Appl. No.: **75,970**

[22] Filed: **Sep. 17, 1979**

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Sep. 21, 1978	[JP]	Japan	53-117239
Sep. 21, 1978	[JP]	Japan	53-117241
Jan. 30, 1979	[JP]	Japan	54-9333
Jan. 30, 1979	[JP]	Japan	54-9334
Jan. 30, 1979	[JP]	Japan	54-9335
Jan. 31, 1979	[JP]	Japan	54-10189

[51] **Int. Cl.**^{3} **G01D 15/18**

[52] **U.S. Cl.** .... **346/140 R**

[58] **Field of Search** .... 346/140 R, 140 PD, 140 A

[56] **References Cited**

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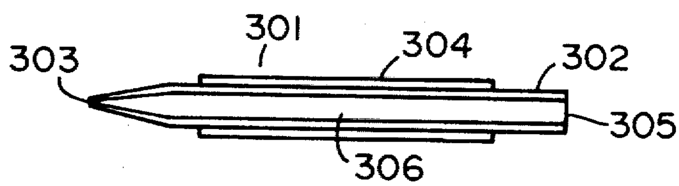
Primary Examiner—Joseph W. Hartary

Attorney, Agent, or Firm—Fitzpatrick, Cella, Harper & Scinto

[57] **ABSTRACT**

A liquid jet recording device is provided with a cleaning protective means for cleaning and protecting the orifice. This means is provided at a reset position lying at one end of the scanning shaft of the device.

9 Claims, 25 Drawing Figures



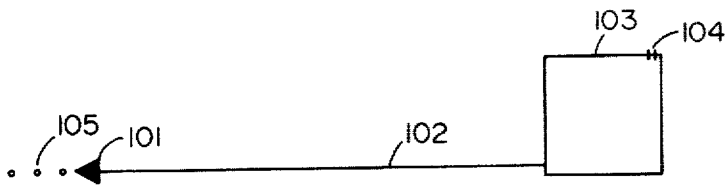


FIG. 1 PRIOR ART

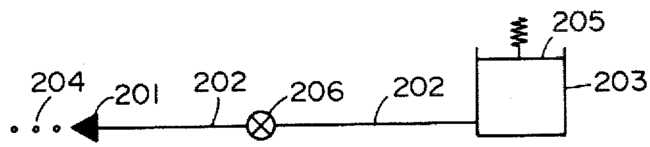


FIG. 2 PRIOR ART

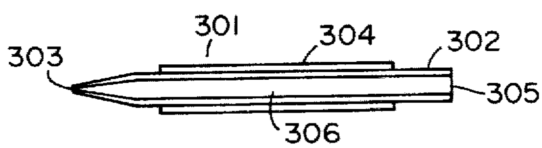


FIG. 3

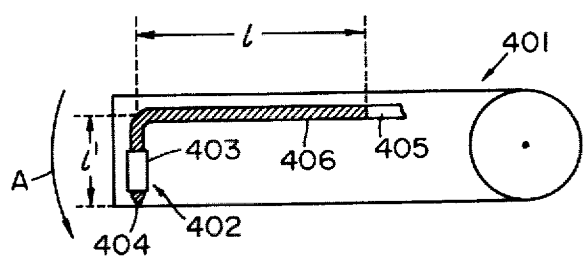


FIG. 4

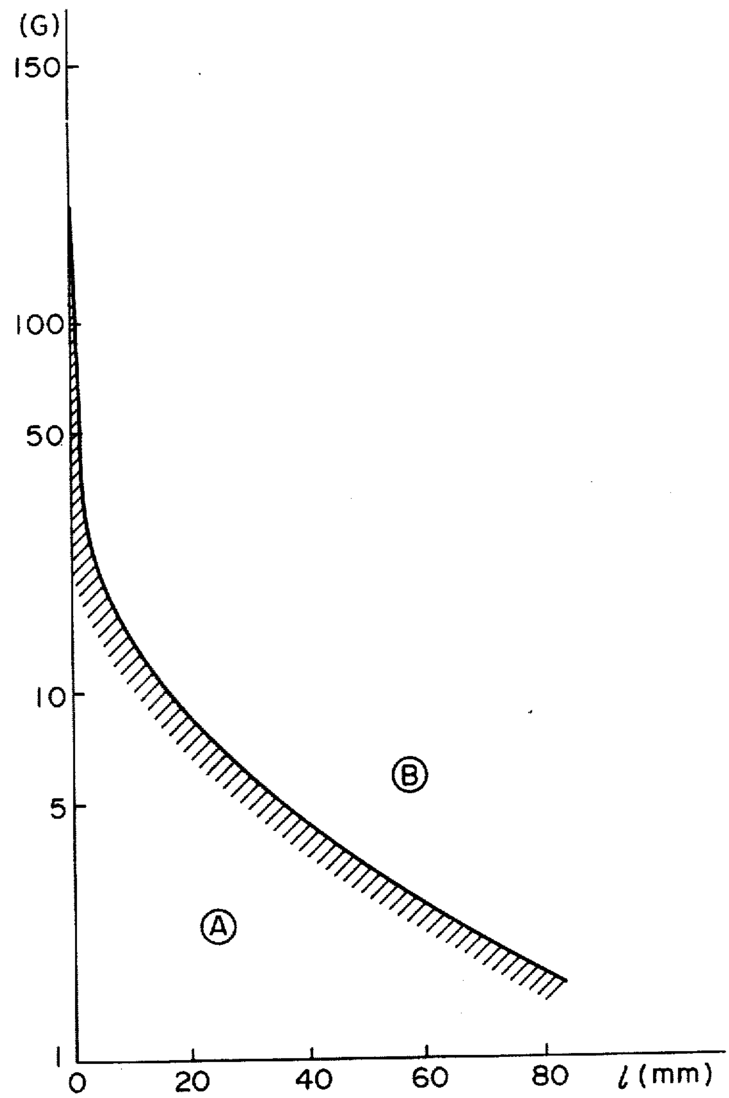


FIG. 5

FIG. 6a

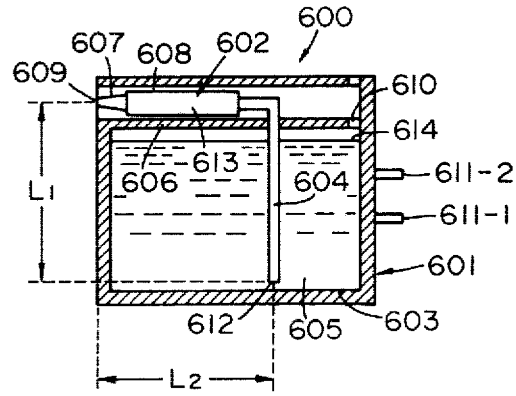


FIG. 6b

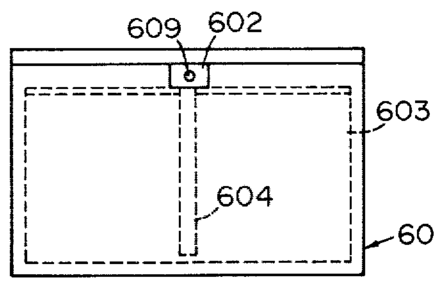


FIG. 6

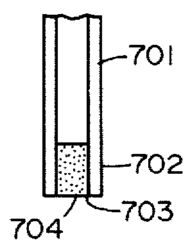


FIG. 7

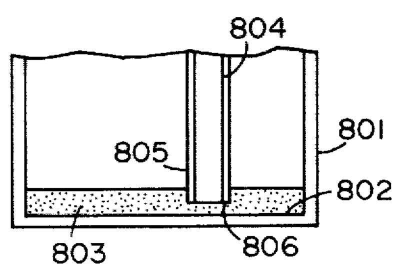


FIG. 8

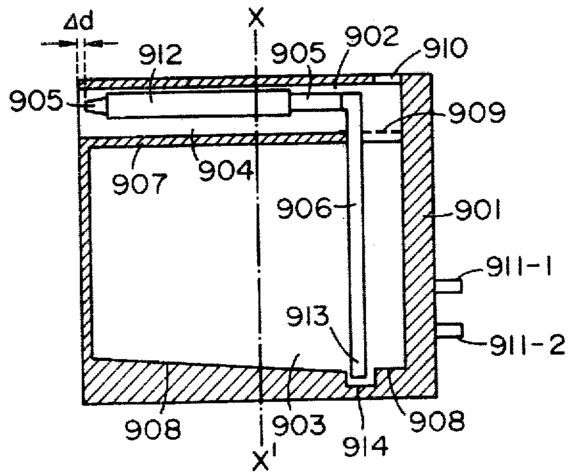


FIG. 9

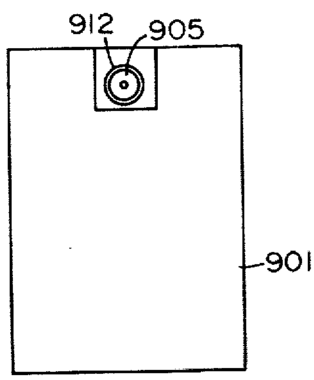


FIG. 10

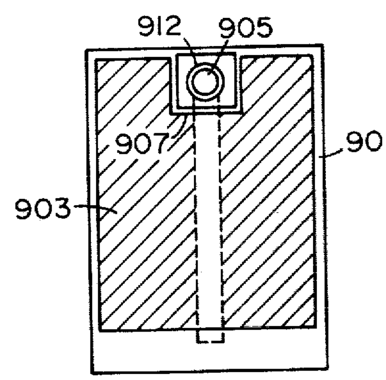


FIG. 11

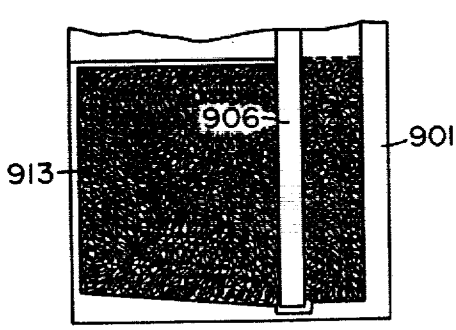


FIG. 12

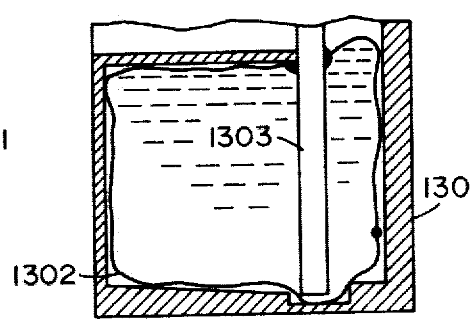


FIG. 13

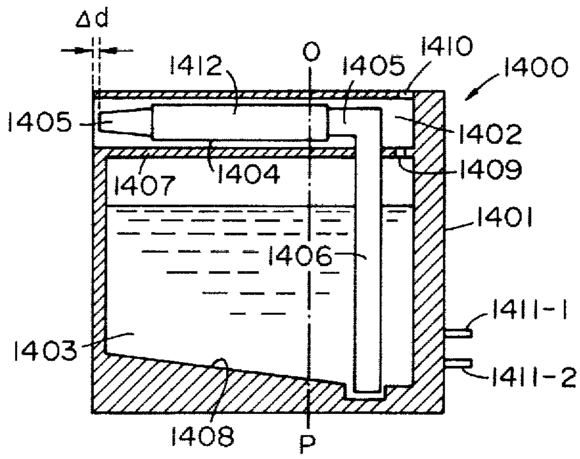


FIG. 14

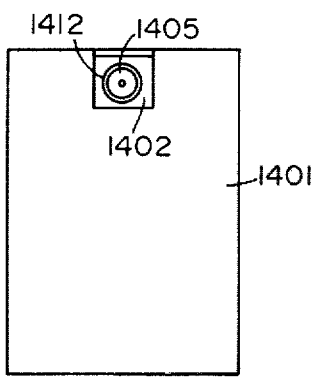


FIG. 15

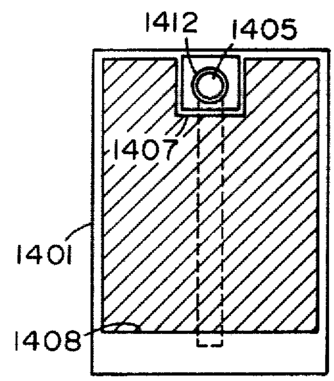


FIG. 16

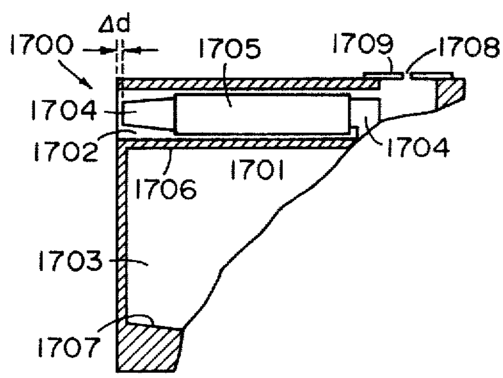


FIG. 17

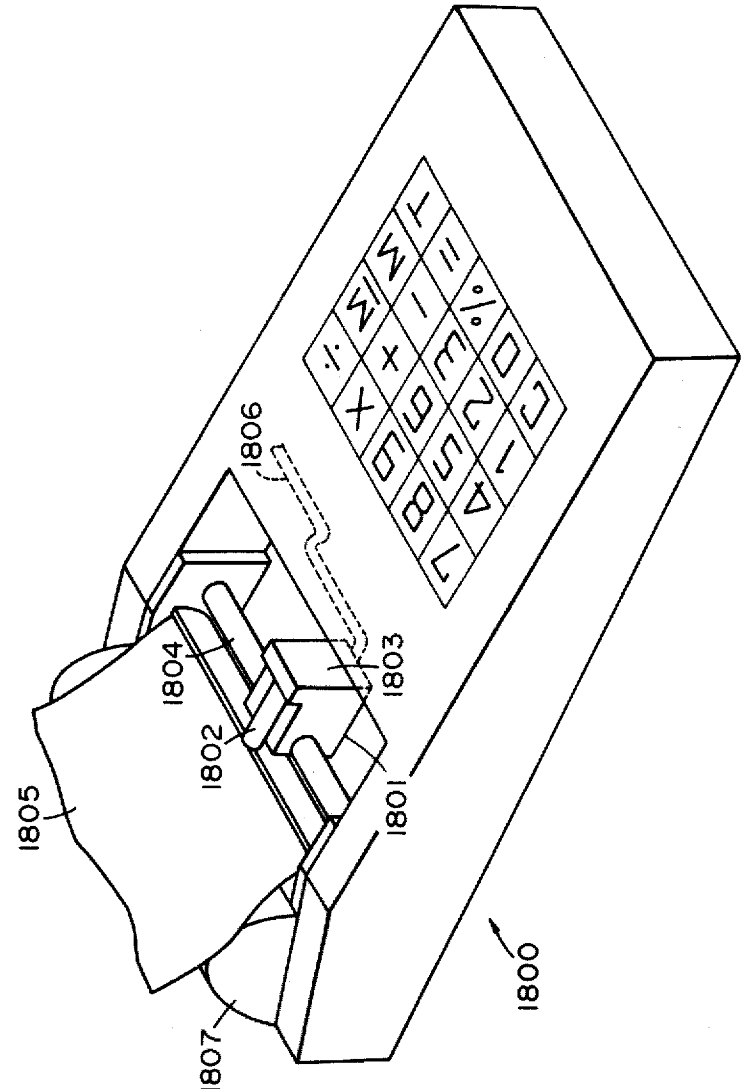


FIG. 18

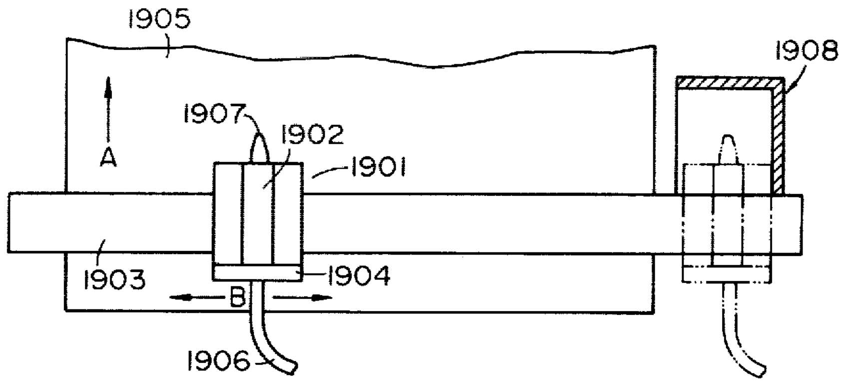


FIG. 19

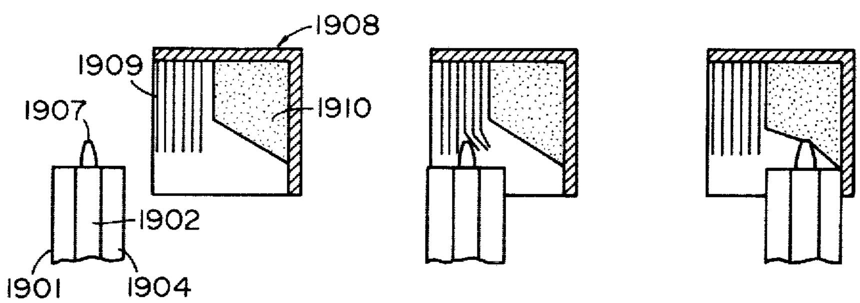


FIG. 20a FIG. 20b FIG. 20c

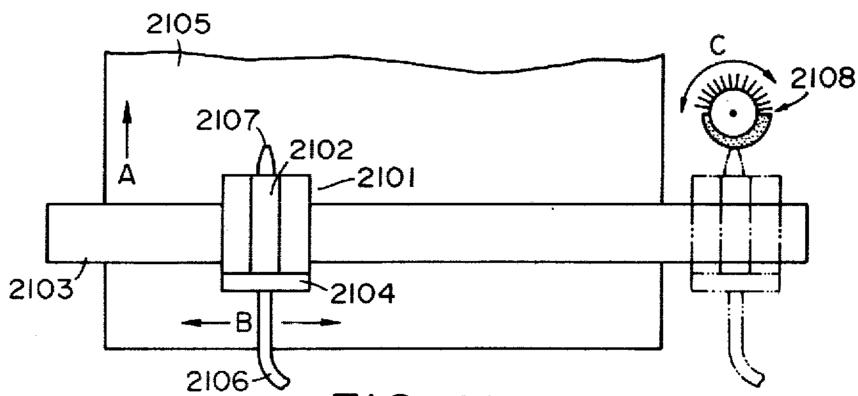


FIG. 21

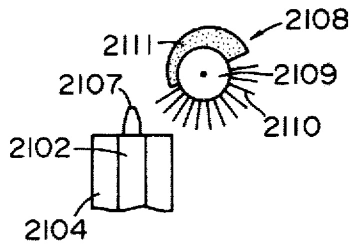


FIG. 22a

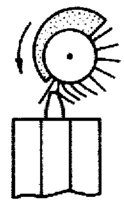


FIG. 22b

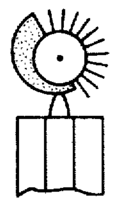


FIG. 22c

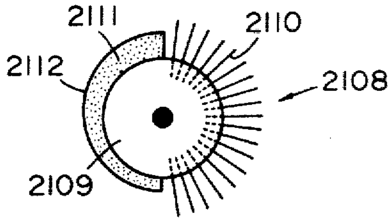


FIG. 23

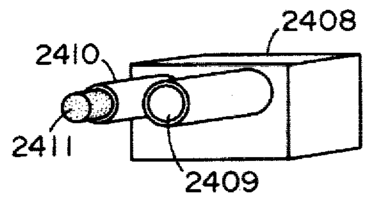


FIG. 25

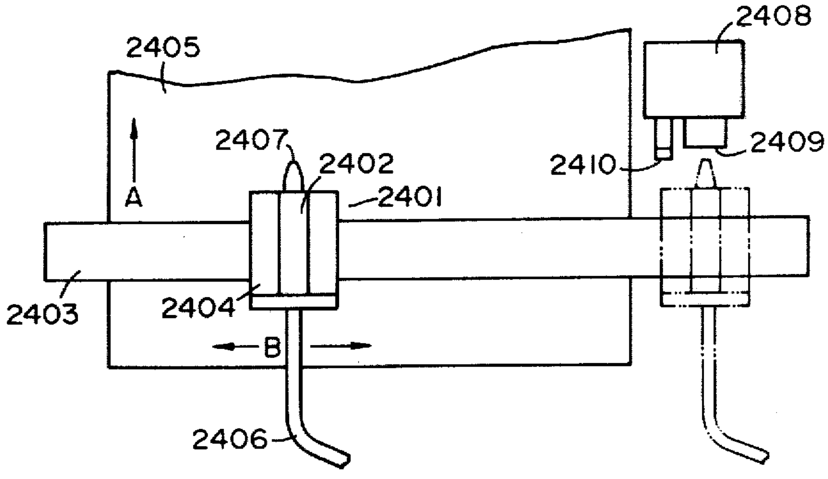


FIG. 24

LIQUID JET DEVICE WITH CLEANING PROTECTIVE MEANS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a liquid jet device for exhausting and flying liquid drops through an orifice in accordance with an electrical signal and to a liquid jet recording apparatus provided with the same.

2. Description of the Prior Art

In a liquid jet recording apparatus, the open system supply mechanism as shown in FIG. **1** of the accompanying drawings is possible in principle as a feature thereof. That is, in a system filled with recording liquid (so-called ink) from a tank (liquid reservoir) **103** having a vent hole **104** so as to always maintain the pressure within the tank at the atmospheric pressure to a recording head **101** through a supply passageway **102**, the amount of decrease of the recording liquid exhausted as liquid drops **105** from the end of the head **101** (exhaust orifice) in accordance with an electrical signal applied to the recording head **101** may be successively replenished to the end of the head **101** by the surface tension of the liquid. However, where such a system is applied to various recording apparatuses, there occur various problems. First, when the apparatus body is inclined, a height difference (level difference) occurs between the tank **103** and the exhaust orifice due to some degree of distance present from the tank **103** to the end of the head **101** and the meniscus of the recording liquid formed by the exhaust orifice may be retracted toward the supply passageway or conversely, the liquid may leak from the exhaust orifice. Accordingly, in case of the retraction of the meniscus, the meniscus can be recovered as by pressing the liquid from the tank **103** side, but in the case of the leakage, the interior of the apparatus is stained with the liquid. Such inclination often occurs during transportation or movement of the apparatus and frequently occurs in the case of, for example, a desk-top type calculator or a small typewriter. Therefore, if the recovery of the retracted meniscus must be effected or the interior liquid leaks each time the apparatus is moved, such apparatus cannot be a practical product.

Also, when agitation or impact is imparted to the apparatus, the leakage of the liquid and the retraction of the meniscus resulting from said inclination of the apparatus are accelerated. That is, when an extraneous stress such as agitation or impact is applied to the apparatus body or the supply passageway **102**, the meniscus in the exhaust orifice is readily destroyed by such extraneous stress and the liquid is exhausted outwardly as liquid drops or the meniscus is retracted. At this time, when the apparatus is in its inclined condition, namely, when there is a level difference, the once destroyed meniscus cannot readily restore its original condition but may continuously leak outwardly or may be retracted in the supply passageway to a position in which a balanced condition may be maintained. Such agitation or impact usually frequently occurs, and always occurs particularly in the case of an apparatus in which the recording head **101** is reciprocally moved relative to a recording medium to effect recording.

A further important problem to be solved is that when recording is effected with the recording head being reciprocally moved at high speed relative to a recording medium such as paper or the like as in a small printer, the supply passageway is vibrated following the movement of the head **101** with a certain point on the tank **103** side as a fulcrum. At this time, the liquid contained in the supply passageway **102** is subjected to the influence of centrifugal forces, and the centrifugal forces so applied increase as the mass of the liquid contained in the supply passageway **102** is greater or the speed of the reciprocal movement is greater. When these centrifugal forces overcome the retention force of the meniscus, the liquid is caused to flow out through the exhaust orifice even if a print signal is not applied to the recording head. This means that the apparatus and the recording medium are stained with the liquid, and it is a fatal drawback in practice.

To avoid such inconvenient phenomenon resulting from the reciprocal movement of the recording head portion during recording, liquid jet devices designed so that the recording head portion and the tank portion (liquid reservoir portion) are moved together are disclosed, for example, in U.S. Pat. No. 3,953,862, U.S. Pat. No. 3,967,286 and U.S. Pat. No. 4,095,237.

To overcome the above-noted inconvenience, the liquid jet devices disclosed in these patents are not only designed so that the recording head portion and the liquid reservoir portion are moved together, but also improved so that when the device is reciprocally moved during recording, the liquid may not leak from a vent hole provided in the liquid reservoir portion as the result of the vibration of the liquid in the liquid reservoir portion caused by the acceleration and deceleration or air may not be mixed with the liquid.

However, in the liquid jet devices having constructions as disclosed in these prior arts, the positional relation between a liquid chamber for producing the motive power of the requid jet of the recording head portion and the liquid level in the liquid reservoir portion is random, so that the exhaust of the liquid becomes unstable with the lowering of the level of the liquid in the liquid reservoir portion and the supply of the liquid to the liquid chamber cannot be accomplished smoothly and speedily, and the probability with which the supply passageway is clogged is high because a portion of such liquid passageway from the liquid reservoir portion to the liquid chamber lies below the bottom surface of the liquid reservoir portion, and when the supply passageway is clogged, it is difficult to repair the clogged portion. Thus, the devices according to the prior art should be improved in these points.

It will thus be understood that from these practical problems, it is very difficult for the open system supply mechanism which is possible in principle to be applied to an actual recording apparatus.

In contrast, there is a liquid jet recording apparatus having a so-called hermetically sealed system supply mechanism. As shown in FIG. **2** of the accompanying drawings, this system has a pressurizing mechanism **205** in a tank **203** and adopts a method whereby the amount of decrease of the liquid exhausted from a head **201** is replenished by opening-closing of a valve **206** provided in a supply passageway **202**, or the tank **203** is designed similarly to the tank **103** of FIG. **1**, namely, such that the internal pressure of the tank is identical to the atmospheric pressure and the tank **203** is provided with no special pressurizing mechanism but a pressurizing mechanism is provided in the valve **206**. The opening-closing of the valve **206** may be accomplished in accordance with a signal from a liquid amount detector such as a pressure sensor provided adjacent to the head **201** or in the supply passageway **202**. The portion from the valve **206** to the head **201** can be considered to be a hermetically sealed system and therefore, the aforementioned problems occurring to the open system may be considerably reduced. However, this hermetically sealed system supply mechanism, as will be appreciated from the simple illustration of FIG. **2**, requires a complicated mechanism and involves a considerable cost and cannot make the best use of its characteristics.

The inventors have analyzed the problems peculiar to the open system supply mechanism and as a result, could develop a liquid jet recording apparatus which is very simple in construction and which has a practically sufficient printing stability and reliability.

SUMMARY OF THE INVENTION

It is a primary object of the present invention to provide a liquid jet device which eliminates the disadvantages peculiar to the liquid jet device according to the prior art.

It is another object of the present invention to provide a liquid jet recording apparatus which is simple and compact and which has a high printing stability and reliability with respect to extraneous forces such as vibration, impact and inclination.

It is still another object of the present invention to provide a liquid jet recording apparatus in which stable liquid supply can always be accomplished even during highspeed recording so that recording can be accomplished faithfully and reliably in response to recording signals.

It is yet still another object of the present invention to provide a liquid jet device which comprises a recording head portion provided with an orifice provided at the end of the recording head portion for exhausting liquid therethrough, a liquid chamber portion communicated with the orifice, a supply passageway for supplying the liquid to the liquid chamber portion, and liquid drop exhaust energy generating means mechanically coupled to at least a part of the liquid chamber portion in such a coupled relationship that liquid drop exhaust energy can be supplied to the liquid present in the liquid chamber portion; a liquid reservoir portion connected to the head portion so that the liquid present in the interior is supplied to the liquid chamber portion from an inlet at one terminal end of the supply passageway; and extraneous electrical connector means for supplying an extraneous electrical signal to the liquid drop exhaust energy generating means to drive said generating means; said portions and means being movable together, said liquid chamber portion lying at a height from the liquid surface in the liquid reservoir portion whereat the liquid present in the liquid reservoir portion can be suppled to the liquid chamber portion by a capillary force.

It is also an object of the present invention to provide a liquid jet recording apparatus provided with the above-described liquid jet device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1** and **2** illustrate the principles of the open system and the hermetically sealed system supply mechanism of a liquid jet recording apparatus.

FIG. **3** is a basic schematic view of a recording head used in the present invention.

FIG. **4** is a schematic view for illustrating the measuring system according to the present invention.

FIG. **5** is a graph showing the result of the measurement effected by the system of FIG. **4**.

FIGS. **6**(*a*) and (*b*) are a cross-sectional view and a front view, respectively, showing a preferred embodiment of the liquid jet device according to the present invention.

FIGS. **7** and **8** are fragmentary views showing another embodiment of the present invention.

FIGS. **9** to **12** show another preferred embodiment of the present invention, FIG. **9** being a schematic cross-sectional view, FIG. **10** being a schematic front view, FIG. **11** being a cross-sectional view taken along line X-X′ of FIG. **9**, and FIG. **12** being a cross-sectional view of essential portions.

FIG. **13** is a cross-sectional view of essential portions of a further embodiment of the present invention.

FIGS. **14** to **16** show still another preferred embodiment of the present invention, FIG. **14** being a schematic cross-sectional view, FIG. **15** being a schematic front view, and FIG. **16** being a cross-sectional view taken along line O-P of FIG. **14**.

FIG. **17** is a cross-sectional view of essential portions of the liquid jet device according to a further embodiment of the present invention.

FIG. **18** is a perspective view of a small desk-top type electronic calculator having the liquid jet device of the present invention mounted thereon.

FIG. **19** is a fragmentary view of the recording apparatus of FIG. **18** having cleaning protective means added thereto.

FIGS. **20**(*a*), (*b*) and (*c*) illustrate the positional relation between the cleaning protective means and the liquid jet device.

FIG. **21** is a fragmentary view of the recording apparatus of FIG. **18** having another cleaning protective means added thereto.

FIGS. **22**(*a*), (*b*) and (*c*) illustrate the positional relation between said another cleaning protective means and the liquid jet device.

FIG. **23** shows the construction of the cleaning protective means.

FIG. **24** is a fragmentary view of the recording apparatus of FIG. **18** having still another cleaning protective means added thereto.

FIG. **25** is a schematic perspective view showing essential portions of the cleaning protective means.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention has been achieved by carrying out the experiment as described hereinafter as an example while studying it in detail from various points of view.

In a recording apparatus having a liquid jet device, the resistance force against the level pressure resulting from inclination and the acceleration to which the liquid in the supply passageway is subjected may be considered to be the meniscus holding force in the exhaust orifice and the capillary progressing force in the head portion or the supply passageway.

It has already been mentioned that the necessity of the meniscus holding force is important in the liquid jet recording apparatus, but the capillary progressing force in the liquid supply passageway until the liquid comes to the exhaust orifice is also important. This is because, even if retraction of the meniscus occurs due to inclination of the apparatus, if the capillary progressing force is great, the liquid can be moved to the exhaust orifice by the force of the capillary when the liquid level restores its normal level, and the recovery by another means becomes unnecessary.

This meniscus holding force and the capillary progressing force are determined by the diameter of the orifice provided at the end of the recording head, the degree of reduction of area of the fluid flow path to the orifice, and the correlation between the critical surface tension of the material forming the orifice and the surface tension and viscosity of the liquid used.

The meniscus holding force and the capillary progressing force may be considered in the same manner as the capillary rising force in the field of capillary chemistry.

The height to which liquid rises in the capillary due to capillary phenomenon is generally expressed as follows:

$$H=\gamma 2\cos\theta/r\rho g$$

where

H: the height to which liquid rises
γ: surface tension of the liquid
ρ: density of the liquid
r: radius of the capillary
θ: angle of contact
g: gravity acceleration

This equation may actually apply only to an ideal system, but qualitatively it is seen that if γ and ρ of the liquid are constant, the smaller is θ (that is, the critical surface tension γ_c of the wall material is greater than γ) and the smaller is γ, the greater is H. It may be said that the meniscus holding force is great if the material forming the orifice portion is glass or metal which has a high critical surface tension and the diameter of the orifice is small. Also, if the diameters of the flow path in the head to the orifice and the supply passageway are small and the distance to the tank portion containing liquid therein is short, the meniscus will naturally restore its original position immediately even if retraction of the meniscus occurs for some reason or other. Conversely, even if a liquid level pressure variation which will cause leakage occurs, for example, an impact force is applied with the orifice portion underlying, the liquid jumps out from the orifice only when such impact force is applied, but the liquid never flows out continuously.

The present invention has been achieved on the above-described background and is based on the fact that as the result of various experiments and studies, the solution to the aforementioned problems has been found out basically by restricting the difference in height between the recording head portion and the surface of the recording liquid in the liquid reservoir portion and the length of the liquid supply passageway as will hereinafter be described in detail. Also, to achieve the objects of the present invention more effectively, the recording head portion and the liquid reservoir portion are constructed as an integral structure which may be mounted on a movable carriage.

The invention will hereinafter be described in detail with an example of the experiment mentioned, but the invention is not restricted to the scope hereinafter described.

To achieve the present invention, the inventors have carried out various basic studies as to the capillary rising force, the meniscus holding force during inclination of the apparatus, and the meniscus holding force for acceleration. The recording head used for such studies is of the construction as schematically shown in the cross-sectional view of FIG. 3, and comprises a glass tube nozzle **302** (including an orifice **303** and a liquid chamber portion **306**) and cylindrical piezoelectric element **304** as an electromechanical converter. Designated by **303** is an exhaust orifice having a diameter of 0.060 mm. The inner diameter of the glass tube nozzle **302** is 0.6 mm and the full length thereof is 18 mm. The recording liquid used has a surface tension of 45 dyne/cm and viscosity of 3 cps.

When the capillary rising force has been measured with respect to various tubes, a glass tube of 0.6 mm has presented 45 mm, a polyethylene tube has presented 16 mm, and a Teflon tube has presented 0 mm. Also, in the case of a combination of pure water and a glass tube, the capillary rising force has been 58 mm. When the meniscus holding force is measured with a polyethylene tube of the same diameter as the glass tube nozzle **302** of the recording head similar to that shown in FIG. **3** being connected to the end **305** of such glass tube nozzle, retraction of the meniscus and leakage do not occur up to the difference of 100 mm in level from the liquid surface in the liquid reservoir portion. However, when a light vibration is imparted to this device, liquid leakage and retraction of the meniscus occur at the level difference of 60 mm. Further, to measure the meniscus holding force for acceleration, the recording head with the aforementioned polyethylene tube has been disposed on a rotation type acceleration generator in the manner as shown in FIG. **4**, and measurement has been made of the meniscus holding force for the amount of recording liquid contained and acceleration in the tangential direction. In FIG. **4**, reference numeral **401** designates the rotation type acceleration generator which is rotatable in the direction of arrow A. Designated by **402** is the recording head, **405** the polyethylene tube, and **406** the liquid filling the passageway in the tube. The axis passing through the center of the exhaust orifice **404** is the tangential direction with respect to the direction of rotation, and the length of the liquid filling the supply passageway extending along the direction in which centrifugal force acts is indicated by l.

The result of the measurement carried out in the described manner is shown in FIG. **5**. In FIG. **5**, the area A is a portion in which the liquid can be stably exhausted, and the area B is a portion in which liquid leakage or retraction of the meniscus seriously occurs so that no stable exhaust is not effected. The meniscus holding force in the nozzle portion (the portion l') for a gravity acceleration G is as great as 140 G, but when liquid is present in the interior (polyethylene tube) of the supply passageway (the portion l), an acceleration corresponding to the mass of such liquid is applied and for l=80 mm, leakage has accured at the order of 1.5 G. This leads to a result that when the supply passageway l is moved at high speed in accordance with the movement of the recording head **402**, liquid always leaks from the exhaust orifice **404** even if the piezoelectric element **403** is not driven.

From the foregoing fact, it is seen that where a supply tube having an inner diameter of the order of 0.6 mm is used, if the height difference between the exhaust orifice and the surface of the liquid, in other words, the height difference between the exhaust orifice and the inlet port at the end of the supply system, is maintained at 50 mm or less, leakage of the liquid or retraction of the meniscus has hardly occurred even if the apparatus is left in any inclined position and even if vibration or impact is imparted to the apparatus. Also, when the supply passageway connecting the recording head portion to the liquid reservoir portion has been designed so as to be movable with the recording head, no liquid has leaked from the exhaust orifice during the recording even if a very great acceleration has been applied. This makes an open system supply mechanism substantially possible in principle. In order to apply these basic matters to an actual recording system, the recording head portion and the liquid reservoir portion may be made integral with each other.

FIG. 6 shows a preferred embodiment of the liquid jet device in which the recording head portion and the liquid reservoir portion are made integral with each other so as to satisfy the basic conditions for achieving the objects of the present invention.

FIG. 6(*a*) is a schematic cross-sectional view of the liquid jet device, and FIG. 6(*b*) is a schematic front view thereof. The recording head portion **602** and the liquid reservoir portion **603** are integrally contained in a single container **601**. The recording head portion **602** comprises an exhaust orifice **609** provided at the end thereof for exhausting liquid, a cylindrical piezoelectric element **608** as an electromechanical converter which is means for generating liquid drop exhaust energy which is the motive power for exhausting the liquid from the exhaust orifice **609**, a liquid chamber portion **613** surrounded by and mechanically coupled to the piezoelectric element **608** so that the liquid drop exhaust energy is effectively supplied to the liquid present therein, and a supply tube **604** for supplying the liquid **605** from within the liquid reservoir portion **603** to the liquid chamber portion **613**. The recording head portion **602** is designed and fabricated so that the liquid chamber portion **613** lies at a height from the liquid surface in the liquid reservoir portion **603** whereat the liquid **605** present in the liquid reservoir portion **603** can be supplied to the liquid chamber portion **613** only by the capillary force. The above-described recording head portion is of the type in which a cylindrical piezoelectric element is used as the liquid drop exhaust energy generating means, whereas in the present invention, the recording head portion is not restricted to such type but use may also be made of the recording head of the type as disclosed, for example, in U.S. Pat. No. 3,747,120, U.S. Pat. No. 3,946,398 or German Patent Publication No. 3,843,064.

The supply tube **604** forming a part of the recording head portion **602** is introduced from the recording head body into the liquid reservoir portion **603** so that the liquid **605** in the liquid reservoir portion **603** is directed into the recording head body, and the supply tube **604** is secured by the wall **606** of the container **601** so that it is not moved by vibration or impact. In FIG. **6**, the supply tube **604** is shown as an extension of the nozzle portion **607** of the recording head portion **602**, whereas the supply tube is not restricted to such a construction but, as shown in FIG. **3**, it may be provided by connecting a metal or plastics tube or a glass tube to the recording head. Designated by **610** is the vent hole of the liquid reservoir portion **603** which serves to maintain the pressure within the liquid reservoir portion **603** at a level equal to the atmospheric pressure. Reference numerals **611-1** and **611-2** designate connectors for transmitting an extraneous electrical signal to the piezoelectric element **608** forming the recording head portion **602**, and the piezoelectric element **608** and the connectors **611-1** and **611-2** are connected together by a signal line, not shown. In order that the liquid in the liquid reservoir portion **603** may be supplied smoothly and speedily to the liquid chamber portion **613** by capillary force, design is made so that the height difference L between the exhaust orifice **609** provided at the end of the nozzle portion **607** and the liquid inlet at the terminal end **612** of the supply tube **604** is set to a length which will be defined below. That is, L is defined as the distance L_1 between a straight line parallel to the free surface **614** of the liquid in the liquid reservoir portion **603** and passing through the center point of the terminal surface **612** of the supply tube **610** and a straight line parallel to said free surface **614** and passing through the center point of the orifice **609** (in the drawing, the center axis of the nozzle portion **607**). When the recording is not executed with the container **601** mounted on the carriage in the manner as shown but that side on which the connectors **611-1** and **611-2** are provided is grounded to the carriage surface and the initial exhaust direction of the liquid exhausted from the orifice **609** is made to be just opposite to the gravity direction, namely, when the recording is executed with the container **601** mounted on the carriage so that the free surface of the liquid in the liquid reservoir portion **603** is parallel to the wall surface of the container **601** in which the connectors **611-1** and **611-2** are provided, said L is made to be L_2 shown in FIG. **6**(*a*). In the present invention, the device is designed and manufactured so that the L is within the range shown below, by designing and manufacturing a great variety of recording heads and carrying out the above-described experiment on these heads and by analyzing and studying in detail the data concerning the relation between the capillary rising force and the meniscus holding force and the liquid drop exhaust characteristic obtained as the result of the experiment.

That is, when a recording liquid having a surface tension of 40–60 dyne/cm is used, the inner diameter of the supply tube **604** is usually 0.3–2.0 mm and L is 120 mm or less.

Further preferably, the inner diameter of the supply tube **604** is 0.5–1.2 mm and L is 65 mm or less, and optimally, the inner diameter of the supply tube **604** is 0.5–0.8 mm and L is 50 mm. By determining L within such range, leakage of the liquid from the exhaust orifice or retraction of the meniscus may be prevented even if the container **601** is rotated up and down or inclined.

The lower limit of L is usually determined to about 20 mm in view of the volume of the liquid **605** contained in the liquid reservoir portion **603** and the practical problem involved when the liquid jet device is incorporated into the liquid jet recording apparatus and further the problem of the speed of the reciprocal movement. For example, where the inner diameter of the supply tube is about 0.6 mm, a remarkably good liquid drop exhaust characteristic may be obtained by determining L to 50 mm or less, especially 40 mm or less.

A liquid jet device having a construction similar to that shown in FIG. **6** has been left with the orifice **609** facing upwardly or downwardly, but leakage of the liquid from the orifice **609** or retraction of the meniscus has not occurred. In this case, the inner diameter of the supply tube of such device has been 0.6 mm, L has been 50 mm and the surface tension of the recording liquid used has been 48 dyne/cm. Also, according to the confirmation of the leakage resulting from the acceleration in the tangential direction, no leakage has occurred up to 140 G and it has thus been proved that this device is practically very stable.

As described above, the device of the present invention enables an open system supply mechanism to be effectively applied to an actual recording system. That is, even under various conditions such as vibration, impact, inclination, etc., troubles such as non-exhaust of the liquid, retraction of the meniscus or leakage of the liquid can be prevented and stable exhaust and high reliability of the recording are ensured.

The device of FIG. **6** shows a basic construction which satisfies the requirements of the present invention and may advantageously have various mechanisms added thereto. One important thing is to provide a liquid covering member having continuous fine holes adjacent to the end of the supply tube. As an example of such embodiment, mention may be made of the method as shown in FIG. **7** wherein a liquid covering member **704** is inserted in a liquid inlet **703** at the terminal end **702** of the supply tube **701**, or the method as shown in FIG. **8** wherein a liquid covering member **803** is disposed on the bottom surface **802** of the liquid reservoir portion **801**. In the case of FIG. **8**, the liquid inlet **806** at the terminal end **805** of the supply tube **804** forming the recording head portion is inserted into the interior of the liquid covering member **803** to fix the supply tube **804**.

In the device shown in FIG. **8**, the liquid covering member **803** is disposed only on the bottom surface **802** of the liquid reservoir portion **801**, but the liquid covering member **803** may be contained in the entire liquid reservoir portion **801**.

One of the effects of so providing the liquid covering member at the liquid inlet of the supply tube is as follows. When the device is left in a certain inclined position with a small amount of liquid contained in the liquid reservoir portion, there may be brought about a state in which the liquid inlet of the supply tube and the liquid do not contact each other, but even in such a state, the liquid introduced into the interior of the liquid covering member is sufficiently held and therefore, there is no problem for short-time printing and there is a merit that even if the device is left in said state for a long time, no air bubble is mixed with the liquid when the device next returns to its normal position, thus causing no hindrance to the next printing operation.

Also, by suitably setting the diameter of its internal holes, the liquid covering member may be made to serve also as a filter for preventing the mixing of air bubbles or dust with the liquid. As the liquid covering member, high molecular materials are preferable in that they are convenient to handle or that various shapes, hole diameters and hole densities can be selected arbitrarily. Such materials include polyethylene, polypropylene, polymethyl meta-acrylate, copolymer of methyl meta-acrylate and acrylonitrile, polyvinyl alcohol, polyurethane, synthetic rubber, etc., but materials having a high affinity with the liquid used are desirable for providing the liquid holding force within the liquid covering member and for preventing the mixing of air bubbles with the liquid.

High hole densities are desirable for enhancing the liquid covering and holding force and in the present invention, hole densities of usually 30–90%, preferably 30–70%, may be effectively utilized. An average hole diameter is usually in the range of 5–600μ, and if the liquid covering member is to be utilized also to prevent the mixing of air bubbles or dust, hole diameters smaller than the diameter of the orifice are desirable.

Reference is now had to FIGS. **9** to **12** to describe another preferred embodiment of the liquid jet device according to the present invention. FIGS. **9** to **12** show another embodiment of the liquid jet device according to the present invention. The housing **901** thereof comprises, for example, a rectangular box body of 3 cm$\times$3 cm$\times$3 cm, and has a recording head containing portion **902** and a recording liquid reservoir portion **903**.

The head containing portion **902** comprises a groove of rectangular cross-section provided in the upper portion of the housing **901**, and the recording head **904** as shown in FIG. **3** (or, of course, an ink jet recording head of any other type) is contained in the head containing portion **902**.

A supply tube **906** is connected to the end of a nozzle **905** forming the recording head **904** in such a manner that the supply tube is substantially perpendicular to the nozzle **905**, and the supply tube **906** extends through a partition wall **907** between the head containing portion **902** and the recording liquid reservoir portion **903** to the bottom of the recording liquid reservoir portion **903**. The clearance between the supply tube **906** and the partition wall **907** is hermetically sealed, and the nozzle **905** is contained so that the fore end thereof is retracted somewhat (by a distance Δd) from the fore end of the head containing portion **902**. If the fore end of the nozzle **905** is so retracted, the nozzle **905** may be prevented from being damaged during the transportation of the recording head or during the mounting or dismounting of the recording paper. The recording liquid reservoir portion **903** consists of a portion provided by removing the head containing portion **902** from the housing **901**, and the bottom surface **908** thereof is inclined so that the recording liquid can be effectively supplied to the supply tube **906** even if the recording liquid is decreased in quantity.

A depression **914** is provided in the bottom surface **908** at a position opposed to the terminal end **913** of the supply tube **906** so that the last amount of recording liquid remaining on the bottom of the liquid reservoir portion **903** can be supplied to the supply tube **906**. Also, a filter **909** having micro-holes for rendering the pressure within the recording liquid reservoir portion **903** equal to the atmospheric pressure is provided in the partition wall **907** between the recording liquid reservoir portion **903** and the head containing portion **902**.

This filter **909** has the function of rendering the pressure within the recording liquid reservoir portion **903** equal to the atmospheric pressure, and can sufficiently pass gas therethrough but does not pass liquid therethrough unless the liquid is pressurized to a certain degree, so that the recording liquid cannot flow outwardly within a short time even if the liquid jet device is upset. The filter **909** used may usually have microholes having a diameter of 0.01–20μ, preferably, 1μ or less.

The material forming the filter **909** may be cellulose nitrate, cellulose acetate, polyamide Polyvinylchloride, trifluoroethylene or tetrafluoroethylene, and a product such as FLUOROPORE (trademark) (Sumitomo Electric Ind., Ltd.), Membranefilter (trademark) (Sartorius-Membranefilter GMBH.) or Millpore (trademark) (Japan Millpore Corp.) may be used as the filter.

A hole **910** provided in the head containing portion **902** forming the upper portion of the housing **901** is also a vent hole and such hole **910** may be provided if required.

That is, where the head containing portion **902** is filled with a bulking agent or the like to fix the recording head in and to the head containing portion **902** so that air cannot flow into the vent hole **909** through the opening of the head containing portion **902**, the hole **910** may be provided so that air can flow into the vent hole **909** through the hole **910**.

Conversely, where air can flow into the vent hole **909** through the opening of the head containing portion **902**, the hole **910** is not always necessary.

Electrodes **911-1** and **911-2** are provided on the back side of the housing **901**. These electrodes are terminals for applying a recording signal from outside the recording head to the recording head, and are connected to a piezoelectric element **912** by signal lines, not shown.

Accordingly, when such liquid jet device is used while being mounted on the head carriage of a calculator, typewriter, facsimile, word processor or other recording apparatus, said electrodes **911-1** and **911-2** may be connected to a connector provided on the head carriage, whereby a driving signal may be applied from the head carriage to the recording head.

As shown in FIG. **12**, the recording liquid reservoir portion **903** may be filled with a porous liquid containing member **913** having continuous microholes, and the recording liquid may fill the holes in the liquid containing member **913**.

If the liquid reservoir portion **903** is so filled with the liquid containing member, the recording liquid is confined in each hole and therefore is not moved for sudden vibration or impact, thus substantially preventing waving of the liquid and mixing of air bubbles with the liquid.

FIG. **13** shows a part of a still another embodiment of the present invention in which a bag **1302** formed of soft high molecular film such as polyethylene, polypropylene, polyvinyl chloride or silicon is contained in a recording liquid reservoir portion **1301**. The bag **1302** is filled with recording liquid, and the connecting portion with a supply tube **1303** is hermetically sealed so that even if the recording liquid is gradually decreased in quantity by being exhausted outwardly, the volume of the bag **1301** is also decreased with the decrease of the liquid, thus creating no blank space. Consequently, even if vibration or impact is imparted, no waving of the recording liquid occurs, thus preventing any abnormality from occurring to the exhaust condition of the recording head.

It is also a feature of the present embodiment that when the bag **1302** is employed, the film **909** of FIG. **9** need not be employed.

FIGS. **14** to **16** show a further embodiment of the present invention. The liquid jet device **1400** according to this embodiment is substantially similar in construction to the device of the FIG. **9** embodiment, and the only difference between the two embodiments lies in that the filter **909** is provided in the device shown in FIG. **9**, whereas in the liquid jet device **1400**, a vent hole **1409** is provided instead of such filter.

The vent hole **1409** is provided in the partition wall **1407** between the recording liquid reservoir portion **1403** and the head containing portion **1402** for the purpose of rendering the pressure within the recording liquid reservoir portion **1403** equal to the atmospheric pressure, and the diameter of this vent hole **1409** is 100 μm or less.

By providing such vent hole **1409**, the recording liquid can be smoothly supplied without any variation in the pressure within the recording liquid reservoir portion **1403** even when the recording liquid is decreased in quantity due to the exhaust thereof. Further, since the vent hole **1409** is a fine hole, a film of recording liquid is produced over the vent hole **1409** due to surface tension even when the liquid jet device **1400** is upset, thus preventing the recording liquid from flowing out.

A hole **1410** provided in the head containing portion **1402** forming the upper part of the housing **1401** is also a vent hole, and such hole **1410** may be provided if required.

FIG. **17** schematically shows a part of still another embodiment of the present invention. The liquid jet device **1700** shown in FIG. **17** is provided with a pressing plate **1709** formed of rubber material and provided with a hole **1708** instead of the hole as shown in FIG. **9** or **14**. This is for the following purpose. When the liquid jet device **1700** is upset or dust is mixed with the recording liquid to clog the supply tube or the flow passage in the head **1701** and thereby cause unsatisfactory exhaust, the pressing plate **1709** is pressed with the through hole **1708** closed by a finger or the like to thereby pressurize the interior of the recording liquid reservoir portion **1703** and recover the recording liquid.

An example of the liquid jet recording apparatus having mounted thereon the liquid jet device of the present invention will now be described by reference to the drawings. FIG. **18** shows a small desk-top type electronic calculator **1800** having mounted thereon the device **1801** of the present invention. Designated by **1802** is a recording head portion having a liquid reservoir portion therein. The recording head portion **1802** is integrally mounted on a movable carriage **1803** fitted on a scanning shaft **1804**. The integrally formed carriage **1803** and head portion **1802** are reciprocally moved on the scanning shaft **1804** in accordance with a write instruction and effect printing by exhausting recording liquid (ink) onto a recording medium (recording paper) **1805** from the recording head portion **1802**. The movement of the carriage **1802** is accomplished by a motor or like drive source (not shown). Designated by **1806** is a supply hose for supplying the recording liquid to the liquid reservoir portion provided within the carriage **1803**, and it is connected to a large-volume tank (not shown) installed within the calculator. Denoted by **1807** is the roll of the recording paper **1805**.

FIG. **19** schematically shows a case where cleaning protective means is installed to provide the recording apparatus as shown in FIG. **18** with an additional function. The liquid jet device **1901**, which scans the recording medium **1905** by electrical drive, reciprocally moves on the scanning shaft **1903** and exhausts drops of recording liquid from the exhaust orifice **1907** in accordance with an instruction based on write information, thereby effecting printing on the recording medium **1905**.

On the other hand, when printing is stopped, the liquid jet device **1901** moves on the scanning shaft **1903** and comes to halt at a position indicated by phantom lines which is a reset position. Arrow A indicates the direction of movement of the recording medium **1905**, and arrow B indicates the scanning direction of the liquid jet device **1901**. In the process during which it returns to the reset position, the liquid jet device **1901** pushes the end of the exhaust orifice **1907** into cleaning protective means **1908** provided at the reset position.

FIGS. **20**(*a*), (*b*) and (*c*) schematically shows a cross-section of the cleaning protective means **1908** and an example of this process. When the printing operation has been terminated (FIG. **20**(*a*)) and the liquid jet device **1901** returns to its reset position, a brush-like group of hairs **1909** at the entrance of the cleaning protective means **1908** frictionally cleans the exhaust orifice **1907** (FIG. **20**(*b*)). Subsequently, when the device has been placed at the reset position, the exhaust orifice **1907** contacts a liquid absorbing member **1910** containing a high boiling point solvent (FIG. **20**(*c*).

The liquid jet device **1901** having thus returned to the reset position is cleaned by the brush-like group of hairs **1909** at the entrance of the cleaning protective means **1908** which removes the foreign substances having entered into the interior of the exhaust orifice **1907** or having adhered to the neighborhood thereof during the process of print scanning, and further the liquid jet device is held at the reset position while contacting the liquid absorbing member **1910** containing a high boiling point solvent, so that the liquid jet device is wet with the high boiling point solvent oozing out of the surface of the liquid absorbing member **1910** and in this state, drying of the recording liquid in the exhaust orifice **1907** can never occur.

That is, the exhaust orifice **1907** is held in the cleaning protective means **1908** disposed at the reset position and therefore, even when the exhaust of the recording liquid is continuously stopped for a long period of time or intermittently stopped, the exhaust orifice **1907** is maintained cleaned and protected against the influence of foreign substances or solidification of the recording liquid resulting from the drying thereof.

By so providing the above-described cleaning protective means at the reset position, the exhaust stability of the exhaust orifice is remarkably improved.

The brush-like group of hairs **1909** forming the cleaning protective means **1908** may be provided by hairs consisting of a high molecular compound such as plastics or fiber.

A bundle of resin-coated metal wires may also be used as the brush-like group of hairs **1909**.

The liquid absorbing member **1910** may be formed of a continuous foamed body of flexible plastics which has a good liquid preserving characteristic and which is high is flexibility and wear resistance, preferably a foamed body of polyethylene or polyurethane.

The high boiling point solvent may be any material which is soluble with the recording liquid used and which is odorless and offers no pollution, preferably, polyatomic alcohol such as diethyleneglycol, glycerine or the like if the recording liquid is ink.

FIG. 21 schematically shows a case where another cleaning protective means is installed in the recording apparatus as shown in FIG. **18**, and FIG. **22** shows the action of a rotatable cylinder member forming the essential portion of that cleaning protective means. The liquid jet device **2101**, which scans a recording medium **2105** by electrical drive, is reciprocally moved on the scanning shaft **2103** as it exhausts recording liquid from the exhaust orifice **2107** in accordance with an instruction based on write information, thus effecting printing on the recording medium **2105**.

On the other hand, when printing is stopped, the liquid jet device **2101** moves on the scanning shaft **2103** and comes to halt at a position indicated by phantom lines which is a reset position. Arrow A indicates the direction of movement of the recording medium, and double-headed arrow B indicates the scanning direction of the liquid jet device **2101**. In the process during which it returns to the reset position, the liquid jet device **2101** comes into contact with the cleaning protective means **2108** provided at the reset position. Arrow C indicates the direction of rotation of the cleaning protective means **2108**.

The cleaning protective means **2108** comprises a brush-like group of hairs **2110** and a liquid absorbing member **2111** both attached to the surface of a rotatable drum **2109**, said liquid absorbing member **2111** containing a high boiling point solvent therein, and the action of the cleaning protective means **2108** is such that as shown in FIGS. **22**(*a*) and (*b*), the brush-like group of hairs **2110** on the surface of the rotatable drum frictionally contacts the exhaust orifice **2107** with the rotation of the drum **2109** and removes therefrom any foreign materials mixed with the recording liquid or having adhered to the exhaust orifice during the print scanning (FIG. **22**(*b*)).

Also, the liquid absorbing member **2111** containing a high boiling point solvent which is attached to the surface of the rotatable drum **2109** likewise comes into contact with the exhaust orifice **2107** with the rotation of the drum **2109** (FIG. **22**(*c*)). At this time, the exhaust orifice **2107** becomes wet with the high boiling point solvent oozing out of the surface of the liquid absorbing member **2111** and as a result, drying of the recording liquid on the exhaust orifice **2107** can be completely prevented.

The action of the cleaning protective means **2108** illustrated with reference to FIG. **22** is shown on the assumption that by the rotation of the cleaning protective means due to its frictional contact with the exhaust orifice **2107**, the exhaust orifice contacts the brush-like group of hairs **2110** and the liquid absorbing member **2111**. Consequently, the initial set position is important, but there is no necessity of providing a mechanism for actuating the cleaning protective means **2108** and this leads to a merit that the cleaning protective means can be designed inexpensively and compactly.

If the movement of the device **2101** is associated with the movement of the cleaning protective means **2108** by simple transmission means such as worm gear and wire, more complete cleaning and protection will be ensured.

FIG. **23** illustrates the construction of the cleaning protective means **2108**. The brush-like group of hairs **2110** consisting of plastics or fiber is planted on one half of the circumference of the rotatable drum **2109**, and the liquid absorbing member **2111** consisting of foamed polyethylene or foamed polyurethane is adhesively attached to the other half of the circumference of the rotatable drum. The liquid absorbing member **2111** may be attached with a uniform thickness, but a more reliable effect may be expected if that side of the liquid absorbing member **2111** which first contacts the exhaust orifice **2107** is formed so as to have a smaller thickness, as shown in FIG. **23**. Further, a cover **2112** formed of thin fiber may be attached to the surface of the liquid absorbing member **2111** to prevent the absorbing member **2111** from being damaged.

The liquid absorbing member **2111** contains therein an odorless and non-poisonous high boiling point solvent as already noted.

FIG. **24** schematically shows a case where exhaust orifice cleaning means is added to the recording apparatus as shown in FIG. **18**, and FIG. **25** is a schematic perspective view of such cleaning means. In FIG. **24**, the liquid jet device **2401**, which scans a recording medium **2405** by electrical drive, is reciprocally moved on the scanning shaft **2403** as it exhausts recording liquid from the exhaust orifice **2407** in accordance with an instruction based on write information, thus effecting printing on the recording medium **2405**. On the other hand, when printing is stopped, the liquid jet device **2401** is moved on the scanning shaft **2403** and comes to halt at a position indicated by phantom lines which is a reset position. Arrow A indicates the direction of movement of the recording medium, and double-headed arrow B indicates the scanning direction of the liquid jet device **2401**. The device **2401** placed at its reset position forcibly exhausts the recording liquid to the recovery opening **2409** of a recovery tank **2408** forming the cleaning means, manually or by electrical signal. When the device **2401** is moved toward the print scanning area, the recording liquid adhering to the neighborhood of the exhaust orifice **2407** after the termination of the forcible exhaust is frictionally removed by a liquid absorbing member **2411** attached to a friction opening **2410** provided adjacent to the recovery opening **2409**.

As shown in FIG. **25**, the inner diameter of the recovery opening **2409** is larger than that of the friction opening **2410**, and the length of the friction opening **2410** must be sufficient to directly contact the exhaust orifice **2407**. However, the recovery opening **2409** should preferably be suitably spaced apart from the exhaust orifice **2407**.

Further, the end portion of the friction opening **2410** directly contacts the moving exhaust orifice **2407** and therefore, only the liquid absorbing member **2411** must have its head projected. This is for preventing the exhaust orifice **2407** from being damaged when it is contacted.

The liquid absorbing member **2411** will now be described. The material used for this member should preferably be one which has a high liquid preservation characteristic as already noted and which has such flexibility which will not damage the exhaust orifice when contacting the exhaust orifice and in addition, has a high wear proof. The material should of course have a high resistance to the solvent.

The material may be, for example, foamed resin such as foamed polyethylene, foamed polypropylene, foamed polystyrene, foamed polyvinyl chloride, foamed polycarbonate, foamed polyurethane or foamed polyamide, or yarn or fiber, or sponge.

What we claim is:

1. A liquid jet recording apparatus comprising:

a liquid jet device comprising:

recording head portion provided with an orifice at the end of said recording head portion for exhausting liquid therethrough, a liquid chamber portion communicating with said orifice, a supply passageway for supplying the liquid to said liquid chamber portion, and liquid drop exhaust energy generating means mechanically coupled to at least a part of said liquid chamber portion in such a coupled relationship that liquid drop exhaust energy can be supplied to the liquid present in said liquid chamber portion;

a liquid reservoir portion connected to said head portion so that the liquid present in the interior is supplied to said liquid chamber portion from an inlet at one terminal end of said supply passageway; and

extraneous electrical connector means for supplying an extraneous electrical signal to said liquid drop exhaust energy generating means to drive said generating means;

said portions and means being movable together, said liquid chamber portion lying at a height from the liquid surface in said liquid reservoir portion whereat the liquid present in said liquid reservoir portion can be supplied to said liquid chamber portion by a capillary force; a scanning shaft on which said liquid jet device is reciprocally movable;

cleaning protective means for cleaning and protecting said orifice provided at a reset position lying at one end of said scanning shaft, said cleaning protective means including a rub-cleaning member and a liquid-absorbing member containing high boiling point solvent; and

a recording member containing portion.

2. An apparatus according to claim **1**, wherein said liquid-absorbing member is continuous foam body of flexible plastic.

3. An apparatus according to claim **2**, wherein said flexible plastic is polyethylene or polyurethane.

4. An apparatus according to claim **1**, wherein said high boiling point solvent is polyatomic alcohol.

5. An apparatus according to claim **4**, wherein said polyhydric alcohol is diethylene glycol or glycerine.

6. An apparatus according to claim **1**, wherein said rub-cleaning member includes a brush like group of hairs.

7. An apparatus according to claim **6**, wherein said brush is of plastic or fibers.

8. An apparatus according to claim **6**, wherein said brush is of resin coated metal wires.

9. A liquid jet recording apparatus according to claim **1**, wherein said cleaning protective means has a liquid recovery opening, a friction opening portion provided adjacent to said liquid recovery opening and mounted at a position whereat a liquid absorbing member contacts said orifice, and a liquid recovery tank.

* * * * *